Investigation

# POLLUTION PREVENTION IS DISEASE PREVENTION

## Background Information

It's easy to see how air pollution might harm people's lungs. But can it hurt other organs as well? According to a September 1995 report by the National Association of Physicians for the Environment, air pollution affects virtually every organ and system of the body.

As Dr. Alfred Munzer, former president of the American Lung Association, explained:

> *After all, it's not just the lungs and lower respiratory tract, but also the eyes, the ears, the nose, and the skin that are exposed to environmental pollution. It's not just the lung that serves as a gateway for hazardous pollutants, but it's also the gastrointestinal tract. It's not just lung cancer, but also bladder cancer that's related to smoking. Lead may be inhaled through the lung, but it has an effect on bone, blood, and the central nervous system. Carbon monoxide, too, gains access to the body by the lung, but has its greatest effect on the cardiovascular system.*

Assessing the relationship between exposure to air pollutants and disease is complicated. People are exposed multiple times to both natural and man-made pollutants, in both urban and rural outdoor environments. The quality of indoor air has also been shown to affect health.

Airborne pollutants considered harmful to public health and the environment are: sulfur dioxide ($SO_2$), carbon monoxide (CO), lead (Pb), ozone ($O_3$), particulates, and nitrogen oxides ($NO_x$). All six are regulated under the federal Clean Air Act.

Airborne pollutants may enter the body as volatile gases such as ozone, as liquid droplets such as sulfuric acid, or as particulate matter such as sooty diesel exhaust. Each of these pollutants affects the human body in a specific way.

**"According to the U.S. EPA, vehicle emissions are responsible for 50% of hazardous air pollutants."**

**Figure 4-4-1 Vehicle emissions**

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## Effects on the Body

Let's look at how air pollution affects some organs and body systems besides the respiratory system:

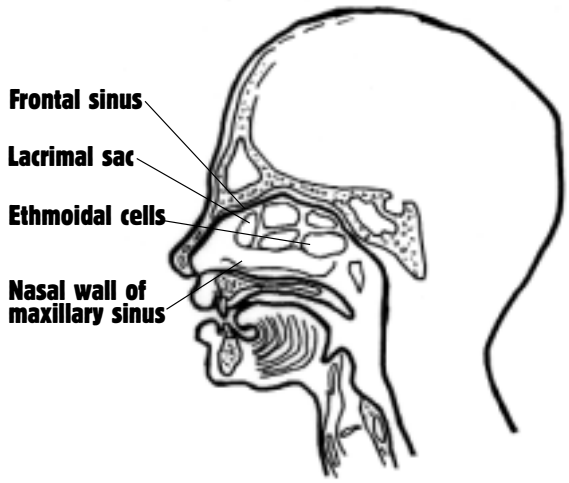


Figure 4-4-2 Nose and throat

### The Nose

Your nose functions as a filter. As it cleans inhaled air, any trapped substances become concentrated. Concentrated pollutants can cause local tissue swelling, **chronic** obstruction of the sinuses, and chronic **sinusitis**.

In addition, some chemicals are absorbed through the nasal mucous membranes. When the body tries to detoxify the chemicals, the **oxidized** pollutants may become more toxic. Pollutants may produce subtle, yet important, changes in the body, weakening the immune system and increasing allergies. People who have allergies may become very sick when exposed to air pollution, and medicine that brings relief under normal conditions may not be as effective after the nose is exposed to pollution.

### Blood

Blood carries oxygen, nutrients, and other beneficial substances throughout the body. It can also carry toxic substances. Blood is constantly changing, with new blood cells entering the circulation as mature cells are lost. This makes the circulatory system especially vulnerable to environmental poisoning.

Airborne chemicals such as benzene, lead and other heavy metals, carbon monoxide, pesticides, and herbicides have been shown to produce harmful effects on the blood and related systems. For example, lead interferes with normal red blood cell formation and cell metabolism, which can result in **anemia**. Benzene exposure may result in a diminished number of blood cells or total bone marrow loss. Benzene and other hydrocarbons are also related to the development of **leukemia** and **lymphoma**. Because these suspected effects can be fatal, many scientists are studying this problem.

# POLLUTION PREVENTION IS DISEASE PREVENTION INVESTIGATION CONT.

### The Heart and Blood Vessels

Recent data implicate several environmental toxins as factors in diseases of the heart and blood vessels—the major cause of death in the U.S. The toxins, including lead and ozone, have been shown to produce high blood pressure (**hypertension**), irregular heartbeat (**arrhythmia**), and kidney failure.

Physicians believe the chemicals produce heart disease by inflaming or damaging **cardiac** and blood vessel tissue. Repeated exposure to pollutants produces a series of changes that lead to heart tissue that is deficient in red blood cells because the inflow of arterial blood is obstructed. Experts have estimated that pollution may cause 10,000 deaths each year.

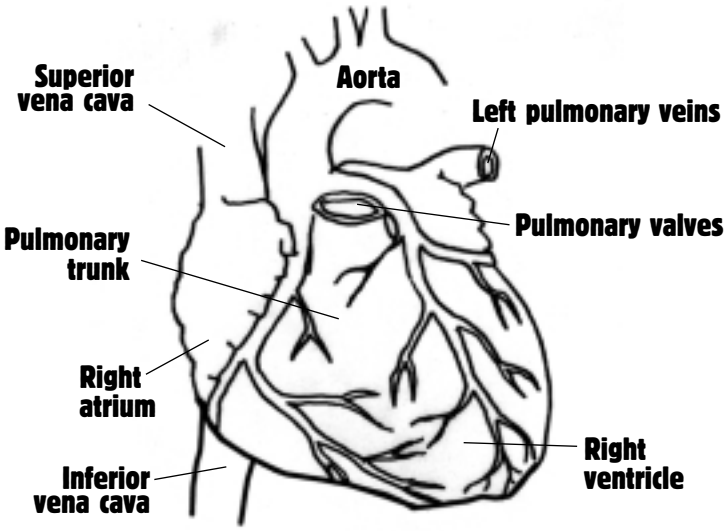


**Figure 4-4-3 Heart, showing coronary arteries**

### The Skeleton

The musculoskeletal system is constantly changing. While bone provides the structural support for the body, it also plays an important role as a reservoir for vital minerals. The tissues in the musculoskeletal system are constantly absorbing and releasing chemicals that circulate through blood. Bone is continuously breaking down and reforming.

As a result, pollutants can be stored in bone and become incorporated into its building blocks. While at first this storage in the bone protects the rest of the body, the toxins are eventually released. Therefore, toxic substances can remain a threat to health for decades. They are especially hazardous when they are released into the blood during critical times of life such as puberty, pregnancy, or menopause. Lead is a particularly dangerous pollutant, because it is found so often in our environment and is so readily taken up by our bones and stored there.

**Figure 4-4-4 Human skeletal system**

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## Effects on the Respiratory System

The lungs are two balloon-like organs within the chest. Their main function is to supply oxygen to and remove carbon dioxide from the blood.

Air enters the body through the nose and mouth. It travels down the windpipe (**trachea**), which divides into two large airways (**bronchi**). At each main bronchus are airways (bronchioles), much like the branches of a tree. The smallest airways are microscopic and form groups of air sacs called **alveoli**. Each air sac is surrounded by a network of small blood vessels called **capillaries**. Between the capillaries and air sacs, oxygen and carbon dioxide are exchanged.

The proper exchange of these gases depends on clear, open air passages. Excessive mucus, particulates, or swelling interferes with the flow of air. Thus, breathing becomes more difficult.

### Asthma and Respiratory Allergies

In controlled medical studies, air pollution has been shown to induce attacks of **asthma**. Ozone enhances the effect of inhaled **allergens** in people with asthma, increasing airway inflammation and making successful treatment more difficult.

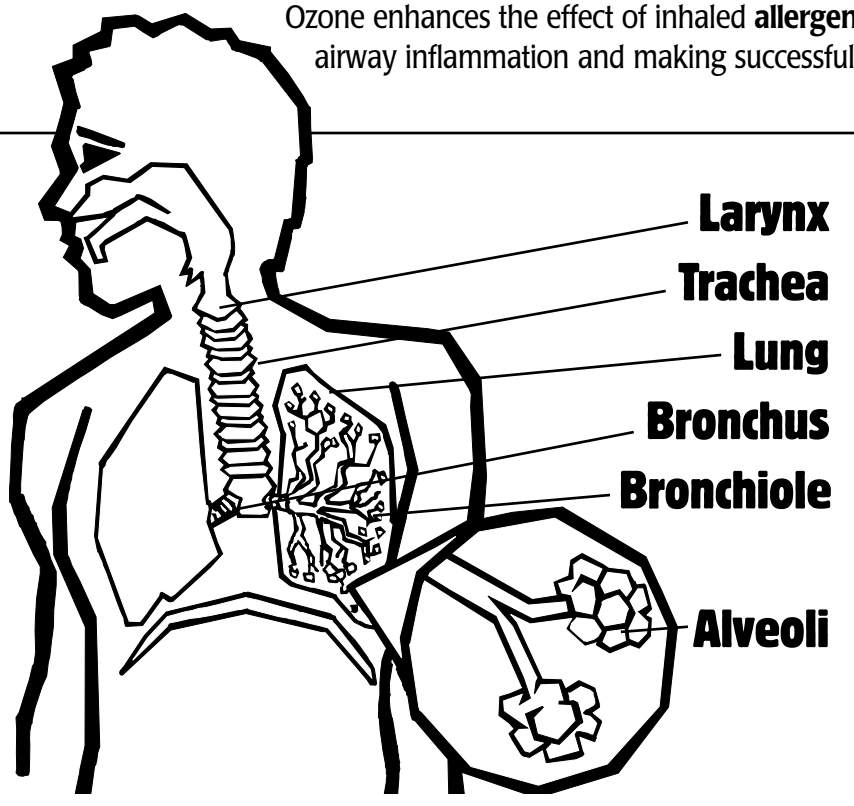


**Figure 4-4-5 Human respiratory system**

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Research by the Johns Hopkins School of Public Health indicates that unless the rate of people suffering from asthma is slowed, asthma will strike 1 in 14 Americans and 1 in 5 U.S. families by the year 2020. Up to 26 million Americans have been diagnosed with asthma, a 12 percent increase since 1988. Asthma is also responsible for an estimated 5,000 U.S. deaths per year. According to the American Lung Association, the rising incidence of asthma correlates with the rising ozone levels in American cities.

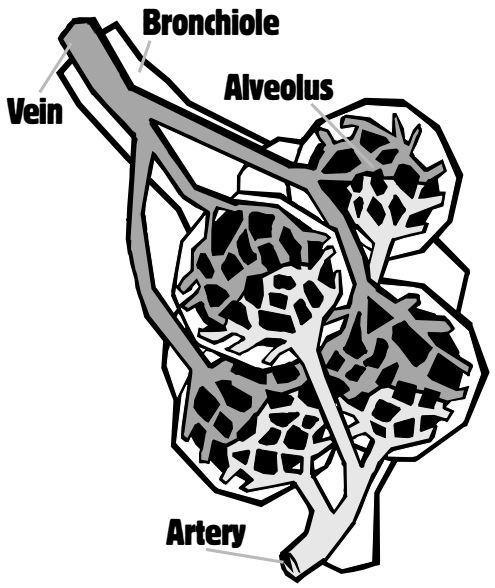


**Figure 4-4-6 A closer look at the alveolus**
*There are more than 300 million alveoli in two adult human lungs. They provide sufficient surface area for gas exchange to handle the needs of the body both at rest and during exertion.*

**Particulates**

Particulate air pollution is a mixture of materials that can include smoke, soot, dust, salt, acids, and metals. Particulate matter (PM) also forms when gases emitted from motor vehicles and industry undergo chemical reactions in the air. PM can be solid particles or liquid droplets that vary in size, composition, and origin. Many particles do not maintain a constant form during their lifetimes in the atmosphere: many clump together to become fewer, larger particles while others react chemically to become different altogether.

U.S. health standards for air quality are based on the concentration of particles that are small enough to be inhaled deep into the lungs. These are particles with a diameter of less than 10 **microns** (one micron is one millionth of a meter). Larger particles, derived chiefly from soil and related materials, tend to deposit in the tracheobronchial region.

Fine-particulate air pollution includes particles with a diameter of 2.5 microns or less—smaller than one-fortieth the diameter of a human hair. They tend to deposit in the alveoli and to remain in

| Particle type | Micron size range |
|---|---|
| *Tobacco smoke* | 0.01 - 1.0 |
| *Bacterium* | 0.3 - 10.0 |
| *Gasoline engine exhaust* | 1.0 - 2.0 |
| *Diesel engine exhaust* | 1.0 - 10.0 |
| *Dust* | 1.0 - 100.0 |
| *Pollen grain* | 10.0 - 100.0 |
| *Human hair (diameter)* | 30.0 - 200.0 |

**Figure 4-4-7 Sizes of typical particulate matter**

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the lungs for long periods of time, because alveoli have a slow clearance system. This means it takes your body a long time to cough up particles caught in the alveoli. Fine-particle pollution typically contains soot, acid condensates, and sulfate and nitrate particles. This type of pollution is thought to pose health risks not only because the particles can be breathed more deeply into the lungs, but also because they are more likely to be toxic than larger particles.

Particulates are likely to become an increasingly important pollution issue. A 1995 Harvard University study of more than 500,000 people, the largest ever on the topic, indicates that the tiniest class of particles may be more dangerous than previously thought. The study showed that areas polluted with the tiny particles experienced higher death rates than other areas, especially from lung and heart disease.

Fine particles are produced by the combustion of petroleum-based fuels used in manufacturing, power generation, and transportation. If you have ever stood behind a diesel-fueled city bus, you know they produce black, sooty smoke. Diesel engines are an easily observed and large-scale source of particulate pollution. Gasoline engines also produce particles, although they are usually not as large and visible as those in diesel exhaust.

One way to cut particulate pollution from vehicles is to use alternative fuels, which produce less particulate pollution than diesel or gasoline. For example, field tests of heavy-duty propane engines for buses showed a 95 percent decrease in particulates compared to an equivalent diesel engine. Natural gas as a vehicle fuel also produces very few particulates.

In the following activity you will create a model of the lungs and diaphragm.

# Materials

a medium-sized clear plastic bottle
scissors
two balloons
1 cotton ball

# Procedure

1. Carefully cut off the bottom half of the bottle. The top part should be about 6 inches tall.

2. Slide a balloon onto the mouth of the bottle and roll the open end over the top edge of the mouth. This will be the lung in your model.

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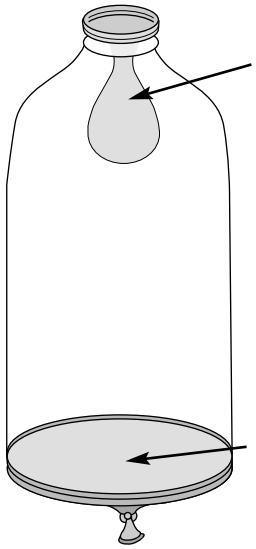
3. Cut off the top of the other balloon.
4. Tie a knot in the bottom of the remaining piece.
5. Slide the cut end around the bottom of the bottle.
6. Pull the bottom balloon carefully downward. What you are observing is similar to what happens when you breathe in.
7. Gently squeeze the sides of the bottle and push the bottom balloon into the space in the bottle. Observe what happens.



**Balloon which represents** _____

**Balloon which represents** _____

8. Place a small piece of cotton inside the balloon to represent particulates lodged in the lung. Repeat steps 6-8 and observe what happens.
9. Label your lung diagram with the part of the respiratory system that it represents.

# Observations

1. What happens to the balloon inside the bottle when you pull down on the bottom balloon?

   _____

2. How does this affect the volume inside the bottle and balloon? _____

   _____

3. What did this represent? _____
4. What happens to the balloon inside the bottle when you gently squeeze the sides of the bottle and push the bottom balloon into the space in the bottle? _____

   _____

5. What did this represent? _____

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6. What happened when you demonstrated particulate matter lodged in the lung? _____

_____

_____

7. What did this represent?_____

_____

8. Explain the limitations of this model and how it could be improved. _____

_____

_____

# Application

9. Carbon monoxide interferes with the blood's oxygen-carrying ability and increases stress on the heart. Explain how CO poisoning of an expectant mother could affect her unborn child.

_____

_____

10. Compare the surface area of the hollow balloon with the surface area of a balloon filled with millions of hollow sacs (alveoli). _____

_____

_____

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# Going Further

11. Even after breathing out, some air remains in the lungs. This air is called residual volume. Since it never leaves the lungs, residual-volume air is not available for gas exchange purposes. In some lung diseases such as emphysema and asthma, residual volume increases because the patient has difficulty clearing his or her lungs. What effect would you expect increased residual volume to have on such a patient's breathing? _____

_____

_____

# Pollution Prevention Is Disease Prevention Resource List

www.lungusa.org
American Lung Association
Information about how lungs work, lung health, effects of air quality on lungs, respiratory disease.

www.epa.gov/airnow/health/
U.S. Environmental Protection Agency
"Smog—Who Does It Hurt?" is a .pdf-viewable brochure about the health effects of ground-level ozone. Topics covered include risks of exposure, concentrations, protective actions for specific levels of exposure.